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Foreign Direct Investment and Technology Spillover: An Evaluation across Different Clusters in India

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Abstract

The paper attempts to explore the technology spillover effects of Foreign Direct Investment (FDI) in Indian manufacturing industries across different selected clusters in India. To measure the spillover effect to domestic firms in a particular cluster, a model is used that combines an innovative production function with a conventional production function. The model parameter estimates provide an evaluation of the technology spillovers in a cluster and the inter-cluster spillovers taking place in various regions. The empirical findings reveal significant variations across clusters in regard to spillovers. While some clusters benefit from foreign firm presence and technological stock within the cluster, a more commonly observed pattern is that domestic firms in a cluster gain from the presence of foreign firms in other clusters of the region and spillovers from technological stock in the regions. In some clusters, productivity enhancing effects of investment climates is visible, but in several others there is no such effect.

Keywords: Foreign Direct Investment; Technology Spillover; Clusters; Firm location.

JEL classification: O41, O1, L6, R12

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1. Introduction

One of the aims in attracting FDI (foreign direct investment) by developing countries is that it will promote regional development. Having foreign firms locate in undeveloped and relatively more developed regions of a country provides a direct impact in terms of employment and capital creation along with a potential indirect effect via technological spillovers to local firms. The primary motive of the multinationals in transferring technology to input suppliers is to make possible supply of high quality inputs at lower prices. Multinationals could diffuse the technology widely – either by direct transfer to additional supplier firms or by encouraging spillover from the original recipient. Wide diffusion of technology would then encourage entry into the input supplier market, thereby increasing competition and lowering input prices. In fact, the multinationals cannot prevent the upstream supplier firms from selling also to others in the downstream markets. The lowering of input prices and cheap accessing of labor in developing economies may induce entry and therefore cause more competition in downstream markets, which in turn would lower prices and therefore lead to more output. Pack and Saggi (2001) show theoretically that, as long as there is not too much entry, profits can rise in both downstream and upstream markets. If so, the new surplus generated from increased productivity and the deadweight loss reduced from increased competition can be split between consumers and producers in a Pareto-improving distribution.[1]

Economic geography in an era of global competition involves a paradox. It is widely recognized that changes in technology and competition have diminished many of the traditional roles of location. Resources, capital, technology, and other inputs can be

[1]Examples of empirical paper measuring technology spillover include Blomstrom and Wolff (1994), Haddad and Harrison (1993), Kokko (1994), Aitken and Harrison (1999), and Haskel (2002).

efficiently sourced in the international markets. Local firms can access the immobile inputs via the corporate networks. Thus, it is no longer necessary for a firm to locate near large markets to serve them. Governments are loosing their influence over competition to global forces. Hence, it is reasonable to conclude that location is diminishing in importance. But, how far is this hypothesis correct for the developing economies? Rather, this idea of location becoming unimportant seems hard to reconcile with the competitive reality. In the *Competitive Advantage of Nations* (Porter, 1990), the microeconomics-based theory of national, state and local competitiveness in the global economy maintains that regional clusters have a prominent role to play, implying thereby that location matters.

This paper focuses on industrial clusters. Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (like universities, standard agencies, trade associations) in a particular field that compete but also cooperate. Clusters or critical masses of unusual competitive success in particular business area are a striking feature of virtually every national, regional state, and even metropolitan economy, especially in advanced nations (Porter, 1998). The regional clusters of a country represent a new way of thinking about national, state and local economies and to various levels of governments and for other institutions they represent new roles for companies in enhancing the competitiveness. The importance of clusters suggests new roles for government at the federal, state and at the local level. Sound macroeconomic policies are necessary but not sufficient for governments to exert more decisive and inevitable influences at the microeconomic level. Among these, removing obstacles to the growth and up-gradation of the existing technology of domestic firms and of the emerging clusters take on a priority.

Clusters are the driving forces for increasing exports and are magnets for attracting FDI. Hence, clusters represent a new type of forum where a new type of knowledge and technology spillovers can occur across domestic firms and this process can be facilitated with proper coordination between government agencies and local market institutions. The present paper tries to examine the technology spillover across ten selected clusters in India. To measure the technology spillover across the selected ten different clusters in India, the study has taken seven broad two-digit level industries (chemicals, metal products, non-metallic mineral products, non-electrical machinery, electrical machinery, transport equipment, and textiles industry) and the clusters have been selected on the basis of the criterion that the cluster should have plants of both domestic and foreign firms. Evidently, to measure the technology spillover in a particular cluster, foreign firm's presence in the cluster is a basic requirement. Thus, clusters have been selected across different regions in India on the basis of the level of foreign firms' presence within the clusters.[2] There is a related issue of location of domestic and foreign firms belonging to an industry, and it may be mentioned in this context that the plant locations of domestic/foreign firms of an industry are distributed across different regional clusters. The main purpose of this analysis is to evaluate the impact of FDI and its associated technology spillover effect in seven selected industries across ten different clusters in India and make an inter-cluster comparative spillover analysis with some cluster/region specific variables in the empirical model.

The rest of this paper is organized as follows: Section 2 deals with conceptual issues of technology diffusion emerging from FDI, covering both forward and backward linkages in the upstream and downstream markets. Section 3 presents the theoretical basis of the empirical model used for the present analysis. Section 4 describes the data (details in Appendix A) and econometric approaches of this analysis, while, Section 5 discusses the empirical results. Section 6 gives the conclusions of the study.

II. Conceptual Issues

Technology diffusion at the industry level for host-country firms is one of the beneficial impacts of FDI. FDI brings new kinds of innovative ideas and generates benefits in the form of technology transfer, management know-how transfer, exchange of knowledge, and export marketing access. Many developing countries are trying to attract FDI to reduce their technological gap in comparison to the advanced nations, upgrade their managerial skills and develop their export markets. Proponents offer three explanations for how technology spillovers occur from multinationals to domestic firms. First, local

[2] The classifications of firms (belonging to seven selected industries) into domestic and foreign firms in the ten different selected clusters across four regions in India is given in the Appendix B, Table B 1.

firms may be able to learn the technological know-how from the foreign counterparts. Second, employees may leave multinational firms to set up own firms or join existing domestic firms of a particular region. Third, multinational investment may encourage the entry of international trade brokers, accounting firms, consultant companies and other professional services which thereafter become available to the local firms contributing to their productivity.

Rodrik (1999) in a summary of evidence relating to technological spillovers states that the local firms enjoy a positive spillover generated by the multinationals firms' entry in the same industry. The fruits of technology spillover in a particular cluster depend on a number of factors that are linked to the quality of microeconomic business environment. Some aspect of the business environment that influence spillovers include the road system of a cluster, corporate taxes, the legal system of the particular area, local labor market regulation and credit facilities of the particular cluster.

Capturing the business environment in a location is challenging given the myriad of locational influences on productivity and productivity growth. A major concern is whether horizontal spillovers can take place in a cluster. First, the technology gap between the foreign and local firms may often be wide in local markets. Local firms may be lacking the absorptive capacity needed to recognize and adopt the new kind of technology. Further, the degree of competition in the local markets of a particular cluster may vary between the local and foreign firms. Due to differences in the quality, technology and other attributes which occurs because the exported and domestically consumed goods entail different production methods, the potential for the technology transfer may be severely restricted in a situation where multinationals are mostly engaged in exports. Second, multinationals may enact measures to minimize technology leakages to the local competitors. And, multinationals with non-secure technology may not enter the market at all if they rely on a technological advantage to sustain rents. In addition, foreign firms often pay higher wages, and this would restrict technology leakage through former employees. In fact, because of higher wages, foreign firms may even draw a capable manager away from the local to the foreign firm in a particular area.

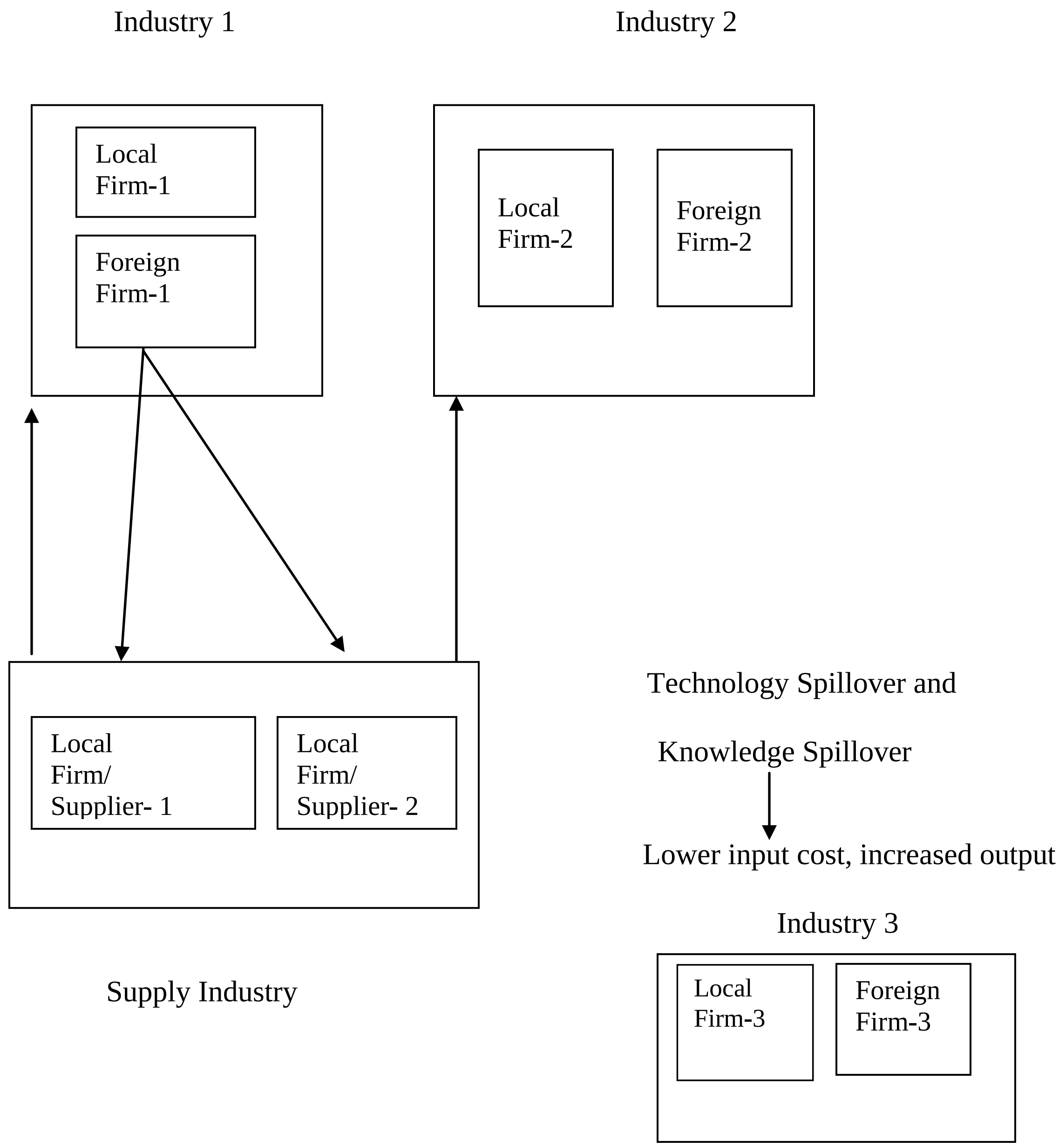
In contrasts, technological benefits to local firms through vertical linkages are much more likely, because foreign firms have incentives to provide technology to local firms/suppliers. Vertical technology transfer could occur through both backward (from buyer to supplier) and forward (from supplier to buyer) linkages.

Many empirical studies have found significant presence of technology spillovers through vertical supply chains. Kenney and Florida (1993) and MacDuffie and Helper (1997) provide a rich description regarding the technology transfer to US parts suppliers following the entry of the Japanese automobile makers. Lall (1980) gives the analytical description of technology transfer from foreign firms through backward linkages in the Indian trucking industry. Blalock et al. (2008) find evidence of technology transfer through the supply chain in production function estimates in Indonesia and Javorcik et al. (2004) find similar results in Lithuania.

The Pack and Saggi (2001) structural model shows that the benefits of a competitive supply base to the multinational buyers outweigh the rents lost to free-loading rivals. In fact, technology diffusion and leakages to other local suppliers can also benefit the initial local recipients. In case technology diffusion to the other upstream firms allows the more capable supplier to enter, then the market concentration and input prices of the provinces are going to fall. Further, given the benefit of lowering input prices, new firms would enter the downstream market. And, a stronger demand in the downstream would in turn prompt a higher output in the upstream market, which would help the initial recipient. Lower prices and greater volume of output increases the welfare of the consumers. The benefits of lower input prices and higher volume outweigh the cost of the greater competition.

The benefit of technological spillovers between the multinationals and their supplier, and the associated benefits accruing in the form of lower input prices and higher volumes of production could provide benefits also to local firms belonging to a third industry that is not vertically connected with either the multinationals or their suppliers. These benefits to a third group of local firms which lie outside the affiliation may accrue because of knowledge and technology spillover among the domestic firms in a particular cluster. The structural framework of technology flow, transfer and technology spillover is depicted in Fig. 1. The mechanism of inter-industry technology transfer which is a part of the vertical linkages is explained in Fig 1 by covering both backward (from buyer to supplier) and forward (from supplier to buyer) linkages. Further, the figure shows the flow of technology and knowledge spillover to domestic firms belonging to a third industry which are not vertically connected with the foreign firms of the first or second industry This is the technology spillover to the third industry domestic firms in a cluster without their bearing any cost for these gains in technology.

Fig. 1: Technology Spillover and Flow of Technology from FDI in a Cluster



III. The Model

In this study, the technology spillovers occurring to different industrial firms in different clusters have been analyzed econometrically by using a model that takes into account the different cluster-specific, region-specific, industry-specific and the firms-specific effects. A set of variables are used to capture these different kinds of effects on the productivity of domestic firms within a cluster. To explain the concept more clearly, we develop an innovative production function for each cluster k at time t which has the form of a constant elasticity of substitution (CES) production function. The functional relationship is specified as follows:

$$A_{kt} = \tilde{A}_k \left(\delta_k R_{kt}^{-\rho} + (1 - \delta_k) R_{ht}^{-\rho} \right)^{-\frac{1}{\rho}} \qquad k = 1, \ldots\ldots\ldots\ldots\ldots\ldots n. \qquad (1)$$

In this equation, A_{kt} denotes the level of technology in cluster k at time t, R_{ht} is the stock of technological knowledge (measured by the cumulative investment in R&D) developed in region h existing at time period t, R_{kt} is the stock of technological knowledge (measured by the cumulative investment in R&D) developed in cluster k of the region h existing at time period t, and $\tilde{A}_k$ is a cluster-specific constant term, which captures the intrinsic efficiency in the technological (innovative) production function. We consider four regions: northern, western, eastern and southern regions of India. Thus, $h = 1, \ldots\ldots\ldots, 4$. Similarly, $k = 1, \ldots\ldots\ldots, 10$, meaning thereby that we are taking ten selected clusters across the four regions of India. ρ is the substitution parameter, which reflects the substitution possibilities between R_{ht} and R_{kt}, i.e. to what extent a cluster may be able to improve its technology level from overall R&D investment in the region as against R&D investment done in the cluster itself. In the equation above, δ is the distribution parameter, and it should lie between zero and one.

The constant elasticity of substitution innovative production function gets converted to the constant returns to scale Cobb-Douglas production function when $\rho = 0$. Hence, the innovative production function can be re-expressed by logarithmic second order Taylor series expansion around the point $\rho = 0$, which is as follows:

$$\ln A_{kt} = \ln \tilde{A}_k + r_{kk}.\ln R_{kt} + r_{kh}.\ln R_{ht} + \frac{\rho}{2} r_{kl}.(\ln R_{ht} - \ln R_{kt})^2 \qquad (2)$$

In this equation, $r_{kk}.r_{kh} = r_{kl}$.

Next, we consider the production function that relates output of firms to their input use (the function is allowed to differ across clusters, and the efficiency parameter is allowed to vary across industries within a cluster). The production function is specified as:

$$Y = AF(K, L) \qquad (3)$$

where Y denotes output (value added), K stands for the capital input, and L stands for the labor input. A is the efficiency parameter, which is determined by the level of technology and also by technology spillovers from different clusters in India and those within clusters. This is incorporated into the production function to develop the empirical model.

For empirical application, after adding the error term and assuming a Cobb-Douglas functional form, the production function in (3) above may be written as:

$$Y_{ijkt} = A_{kt} (K)^{\alpha}_{ijkt} (L)^{\beta}_{ijkt} \; e_{ijt} \qquad (4)$$

The subscript *ijkt* refers to *i*th firm in *j*th industry in *k*th cluster at time *t*. If we divide both sides of Eqn. (4) by L,[3] then the equation becomes:

$$y_{ijkt} = A_{kt} (K/L)^{1-\beta}_{ijkt} \; (K)^{\alpha+\beta-1}_{ijkt} \; e_{ijt} \qquad (5)$$

where y =*Y/L*. Now, if we take the logarithmic transformation of the above equation then it becomes:

$$\ln y_{ijkt} = \ln A_{kt} + \beta_1 \ln (K/L)_{ijkt} + \beta_2 \ln K_{ijkt} + \varepsilon_{ijt} \qquad (6)$$

In the above equation, we may treat A_{kt} as the level of the technology in clusters k at time t and is therefore determined by the cumulative R&D investments done in the cluster k and in region h as described by equations (1) and (2). y_{ijkt} stands for the labor productivity of the *i*th firm in *j*th industry of the *k*th cluster at time (year) *t*. As mentioned

[3] We are following the theoretical approach for productivity determinants at a firm/industry level from the paper by Kohpaiboon (2006). Following that paper, labor productivity of a firm in an industry has been determined by dividing output (value added) of the firm by the labor input used in that firm.

earlier, we consider seven industries in 10 clusters. The period considered for the econometric analysis is from 2000 to 2007.[4] K_{ijkt} represents the capital input of the *i*th firm in *j*th industry of the *k*th clusters over the interval of time, 2000 to 2007, and K/L_{ijkt} stands for the capital intensity and is similarly defined.

If we substitute the value of $\ln A_{kt}$ from Equation (2) in Equation (6), then the extended model becomes:

$$\ln y_{ijkt} = \ln \tilde{A}_k + r_{kk} \ln R_{kt} + r_{kh} \ln R_{ht} + \frac{\rho}{2} r_{kl} . (\ln R_{ht} - \ln R_{kt})^2$$
$$+ \beta_1 \ln(K/L)_{ijkt} + \beta_2 \ln K_{ijkt} + \varepsilon_{ijt} \qquad (7)$$

In the next step, the spillover effects of FDI are incorporated in the model. To incorporate this effect, the constant term in equation (7) above is allowed to vary from industry to industry (subscript *j*). Thus, the constant term changes to $\ln \tilde{A}_k + \mu_{kj}$. Spillovers associated with three types of horizontal FDI are incorporated into the model, which allows the constant term to vary across different industries in a cluster. The first is the effect of horizontal FDI of the clusters (first kind of horizontal FDI effect, H_FDI), and the second is effect of horizontal FDI of the corresponding region (second kind of horizontal FDI effect, H_FDIR). To explain further, the presence of foreign firms in industry *j* within the cluster is reflected in H_FDI, while the presence of foreign firms belonging to industry *j* in other clusters of the region is reflected in H_FDIR. The third kind of effect of horizontal FDI (H_FDIO) is connected with inter-industry spillovers. For each industry *j* in cluster *k*, the variable is measured by taking the output share of the foreign firms to the industry output in the cluster in industries other than *j*. Further details of construction of variables relating to these three different kinds of horizontal FDI spillover effects are given in appendix A. [5]

[4] The data relate to the accounting years of the firms covered in the study, i.e., the data for a firm for 2000 relates to the accounting year ending in some month of 2000. The closing month of the accounting year varies from firm to firm.

[5] An important question that may be raised here is whether μ_{kj} is independent of R_{kt}. Arguably, if a firm invests more into R&D, this may not only make the firm more efficient but also make it more receptive to technological spillovers. The implication is that in the specification of the model one should allow for interactive terms involving R_{kt} and the three FDI effects. This has, however, not been done to keep the model simple.

After inclusion of the three above mentioned kinds of horizontal FDI, the model gets further extended to:

$$\ln y_{ijkt} = \ln \tilde{A}_k + r_{kk}.\ln R_{kt} + r_{kh}.\ln R_{ht} + \frac{\rho}{2} r_{kl}.\left(\ln R_{ht} - \ln R_{kt}\right)^2$$
$$+\beta_1 \ln(K/L)_{ijkt} + \beta_2 \ln K_{ijkt} + \beta_3 H\_FDI_{jkt} + \beta_4 H\_FDIR_{jht} + \beta_5 H\_FDIO_{jkt} + \varepsilon_{ijt} \quad (8)$$

It should be noted that the present analysis considers only labor productivity of the domestic firms. Further, if we simplify the coefficients of the cluster/region-specific technological stock variable coefficients by the symbol γ, then the above discussed model becomes:

$$\ln y^d_{ijkt} = \overline{\chi}_k + \gamma_1 \ln R_{kt} + \gamma_2 \ln R_{ht} + \gamma_3 \ln R_{lt} + \beta_1 \ln(K/L)_{ijkt} + \beta_2 \ln K_{ijkt}$$
$$+\beta_3 H\_FDI_{jkt} + \beta_4 H\_FDIR_{jht} + \beta_5 H\_FDIO_{jkt} + \varepsilon_{ijt} \quad (9)$$

Where $\overline{\chi}_k = \ln \tilde{A}_k$, R_{lt} = $(R_{ht}$-$R_{kt})^2$ and y^d_{ijkt} represents labor productivity of domestic firms in an industry of a particular cluster (*k*th).

Apart from the factors discussed above, some other cluster-specific and firm-specific factors are included in the model. These are (a) market-concentration index of a particular cluster (CON), (b) whether the location of the firm is around the center of the cluster or in the periphery (dummy variable, D1), and (c) whether the firm is located in urban area or rural area (dummy variable, D2). The first variable captures market condition, while the latter two capture availability of infrastructure and other such advantages associated with location. Regarding variable D_1, the hypothesis is that a firm at the center of the cluster is more likely to gain from technological spillovers than a firm at the periphery of the cluster. As regards D_2, the hypothesis is that a firm located in the city/urban area gets access to better infrastructural facilities (banking and credit facilities, roads, telecommunication, electricity, etc) and hence will be more productive. Further, to take into account the dynamic adjustments of lagged effects of the individual heterogeneity in the model, we investigate the lagged effect of endogenous variable by including it in the model. With these changes, the final empirical model becomes:

$$\ln y^{d}_{ijkt} = \bar{\chi}_k + \phi y^{d}_{ijk,t-1} + \gamma_1 \ln R_{kt} + \gamma_2 \ln R_{ht} + \gamma_3 \ln R_{lt} + \delta t + \beta_1 \ln(K/L)_{ijkt} + \beta_2 \ln K_{ijkt} + \beta_3 H\_FDI_{jkt}$$
$$+ \beta_4 H\_FDIR_{jht} + \beta_5 H\_FDIO_{jkt} + \beta_6 CON_{jkt} + \beta_7 D1_{ij} + \beta_8 D2_{ij} + \varepsilon_{ijt} \quad (10)$$

IV. Econometric Approaches and the Data Sets

From an econometric point of view, the analysis follows three familiar estimation methods for the above discussed dynamic panel data model (10). To investigate the relationship between the explanatory variables and the explained variable, we make use of the pooled OLS estimates, Fixed Effects (within group) estimates and finally the Generalized Methods of Moments (GMM) estimates in order to capture the dynamic effects of the lagged endogenous variable. In the present analysis, the application of difference GMM is done to capture the lagged effect of the endogenous variables among the group of explanatory variables either in the level or lagged form. It should be noted, however, that the dynamic feature of the model is the presence of the lagged dependent variable and not the serial correlation that lies in the error term.

The data for the analysis presented in this paper have been collected mainly from the '*Prowess*' dataset of the *Center for Monitoring Indian Economy* (CMIE) for the years 2000 to 2007 and from *Annual Survey of Industries* (ASI).

V. Empirical Results

From the results for the Baddi and NOIDA (New Okhla Industrial Development Area) clusters of the northern region reported in Table 1, it is seen that the first-order autoregressive parameter (ϕ) coefficient is not free from the downward bias because the estimated value of the first difference GMM estimate is not close to the WG estimate. For the other two northern region clusters namely Gurgaon and Bhiwadi also, it appears that the lagged dependent variables coefficients are not free from the bias. Thus, the results indicate that the instruments which we utilized in these dynamic models are not suggestive and informative. However, for the Gurgaon cluster, the first difference GMM estimate for the lagged endogenous variable is to some extent closer to the WG estimate. This implies that the instruments associated in this regression model for the Gurgaon cluster are relatively more reliable and provide suggestive information into the model and for the determination of cluster-specific technology spillover (see Table 2). Selection of the instruments is based on the relevance of the model and statistical significance of the variables so that it can support the Sargan Test of restriction. However, the instruments used for GMM estimates in Baddi and NOIDA clusters (Table 1) are first lagged of labor productivity, three different kinds of horizontal FDI, and three different kinds of technological stock variables as technology stock of the cluster, technology stock of the region and other clusters technological stock but lies in a specified region. The instruments used in other cases are more or less similar shown below the tables and to save space, we have not discussed the instruments used.

Turning to the other parameters in the empirical model across different clusters in the northern region such as the cluster/region-specific technological stock variables, it may be noted that the own technology stock variable in the Baddi cluster is not statistically significant in the OLS and WG level estimate but its coefficient is non-negative and statistically significant at first difference GMM estimate. This suggests that the technology stocks have a positive impact on labor productivity of the domestic firms. But in NOIDA and other clusters like Gurgaon and Bhiwadi, the clusters' own and the regional technological stock variables have a positive impact on the labor productivity of domestic firms. This suggests that greater R&D expenditure of firms in a particular area provides more useful results for the improvement of domestic firms' labor productivity for that area. Moreover, from the OLS estimates in the Bhiwadi region, it seems that both own cluster-specific technology stock and region-specific technology stock, in the northern region, positively affect the labor productivity of the domestic firms.

Table 1: *Model Estimates, Baddi and NOIDA clusters*

Dependent variable: $\ln y_{ijkt}^{d}$

	Baddi			*NOIDA*		
Estimation	*OLS*	*WG*	*GMM (Diff.)*	*OLS*	*WG*	*GMM (Diff.)*
Observations	238	238	198	149	149	125
$\ln y_{ijk,t-1}^{d}$	0.764* (0. 031)	0.503* (0.044)	0.261** (0.141)	0.715* (0.061)	0.189** (0.095)	0.118 (0.042)
R_{kt}	-0.019 (0.052)	0.017 (0.067)	0.130*** (0.080)	0.081 (0.574)	0.686 (0.689)	2.234** (1.140)
R_{ht}	0.513 (0.955)	0.172 (0.908)	-0.354 (0.884)	1.482 (39.519)	33.609 (42.699)	2.662** (5.663)
R_{lt}	-0.513 (0.915)	-0.093 (0.433)	0.183 (0.424)	-0.738 (19.580)	-16.583 (21.152)	-5.737** (27.546)
$\ln K/L_{ijt}$	0.050* (0.013)	0.178* (0.025)	0.498* (0.041)	0.103** (0.105)	0.237*** (0.166)	-0.149 (0.517)
$\text{Ln}\, K_{ijt}$	-0.008 (0.005)	0.053* (0.022)	-0.270* (0.058)	0.054** (0.044)	0.219** (0.196)	1.378* (0.444)
H_FDI_{jkt}	-0.066 (0.077)	-0.097 (0.099)	-0.409 (0.208)	-1.054 (0.782)	1.669 (1.733)	2.682 (2.371)
H_FDIR_{jht}	0.072*** (0.076)	0.092** (0.508)	1.528** (0.956)	2.009** (1.044)	2.285 (3.707)	7.290*** (5.193)
H_FDIO_{jkt}	-0.103 (0.433)	0.174 (0.899)	-0.690 (0.852)	0.324 (0.394)	0.488 (1.156)	-0.200 (0.186)
CON_{jkt}	-0.053 (0.095)	0.371* (0.136)	-1.282* (0.522)	-0.033 (0.441)	-8.045 (6.681)	-8.502*** (5.375)
$D1_{ij}$	-0.051 (0.064)					
$D2_{ij}$	0.038 (0.061)					
R^2	0.855	0.719 (overall)		0.643	0.084 (overall)	
Sargan test of restriction			0.030 (p-value)			0.000 (p-value)

Note: 1.* significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. For the Baddi and Noida clusters, the GMM-Difference instruments are;

$y_{ijk,t-1}^{d}$, $H\_FDI_{jk,t-1}$, $H\_FDIR_{jh,t-1}$, $H\_FDIO_{jk,t-1}$, $R_{k,t-1}$, $R_{h,t-1}$, $R_{l,t-1}$.

Table 2: *Model Estimates, Gurgaon and Bhiwadi Clusters*
Dependent variable: $\ln y_{ijkt}^{d}$

	Gurgaon			*Bhiwadi*		
Estimation	*OLS*	*WG*	*GMM (Diff.)*	*OLS*	*WG*	*GMM (Diff.)*
Observations	165	165	134	101	101	101
$\ln y_{ijk,t-1}^{d}$	0.796* (.039)	0.649* (0.064)	0.635* (0.069)	0.762* (0.053)	0.436* (0.085)	0.625* (0.238)
R_{kt}	0.018 (0.218)	0.170 (0.320)	0.151 (0.351)	0.321** (0.149)	0.011 (0.164)	0.762* (0.338)
R_{ht}	0.731 (1.145)	-0.602 (1.448)	-0.603 (1.632)	13.894* (5.402)	6.750*** (5.058)	-4.145 (7.583)
R_{lt}	0.601 (0.961)	0.285 (0.603)	0.321 (0.683)	13.708* (5.339)	-3.356 (2.499)	2.077 (3.753)
$\ln K/L_{ijkt}$	0.148* (0.040)	0.442* (0.087)	0.979* (0.336)	0.077** (0.038)	0.002 (0.097)	0.835** (0.386)
$\ln K_{ijkt}$	0.063* (0.020)	0.248* (0.061)	0.693* (0.230)	0.010 (0.027)	-0.161** (0.092)	1.124* (0.326)
H_FDI_{jkt}	0.241 (0.124)	-0.103 (0.629)	-0.389 (1.221)	0.956* (0.286)	-1.259 (0.843)	0.408 (1.366)
H_FDIR_{jht}	0.483** (0.498)	0.051 (0.828)	-0.655 (1.217)	0.932* (0.250)	-1.392 (1.117)	-2.347 1.728
H_FDIO_{jkt}	0.581*** (0.436)	-2.009 (1.444)	-4.594* (1.443)	2.67* (0.683)	4.839* (1.292)	7.352* (2.013)
CON_{jkt}	-0.074 (0.153)	-1.026 (0.871)	-3.566 (2.858)	0.213 (0.175)	1.053** (0.536)	-0.809 (1.234)
$D1_{ij}$	0.039 (0.049)			-0.41*** (0.155)		
$D2_{ij}$	0.091 (0.073)			0.341** (0.163)		
R^2	0.793	0.476 (overall)		0.950	0.165 (overall)	
Sargan test of restriction			0.000 (p-value)			0.038 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. For the Gurgaon and Bhiwadi clusters the GMM-Difference instruments are; $y_{ijk,t-1}^{d}$, $H\_FDI_{jk,t-1}$, $H\_FDIR_{jh,t-1}$, $H\_FDIO_{jk,t-1}$, $R_{k,t-1}$, $R_{h,t-1}$, $R_{l,t-1}$

It appears from the results reported in Tables 1 and 2 that domestic firms' labor productivity across all clusters in the northern region has been positively affected by the capital intensity variable. This applies to some extent also to the capital stock variable.[6] The coefficients of capital intensity are found to non-negative across all northern region clusters.

Inferences about cluster-specific technology spillover can be drawn from the estimated coefficients of horizontal FDI. From the reported results in Table 1, it is seen that the own cluster-specific foreign presence does not have a positive impact on labor productivity in the Gurgaon, Baddi and NOIDA clusters. However, for the Bhiwadi cluster, the results are to some extent more satisfactory and so, intra-cluster technology spillovers in this cluster seems to be greater in comparison to other northern region clusters. Region-specific horizontal FDI seems to have a significant positive effect on productivity in all four clusters in northern region. This implies that all domestic firms are getting some benefit from the foreign firms' presence in the northern region rather than their own cluster-specific foreign presence. The coefficients of third kind of horizontal FDI are found to be statistically significant in the OLS estimate for Gurgaon and Bhiwadi. This suggests that in the Gurgaon and Bhiwadi clusters, the domestic firms' labor productivity is enhanced by the positive impact of the foreign presence of other industries apart from the own industry foreign presence.

The analysis is not getting any plausible and supportive results for the concentration index across all clusters in northern region. As regards the investment climate variables, represented by the two dummy variables, the model results do not show any significant impact of these variables. Only in the case of Bhiwadi cluster, there are indications that firms' plant location in the urban areas provides some kind of benefits in terms of scientific and technological, and institutional environment covering credit facilities of banking in comparison to the firm's plant location in the rural areas. However, in NOIDA cluster, the dummy variable D1 and D2 is not included into the model because the study does not cover the rural side plant location firms and firms with plant location farther away 40 km from the core part of the clusters. All firms with plant location in this cluster are within 40 km radius and city/urban areas located firms.

[6] The capital stock variable can have either positive or negative coefficient depending on the returns to scale. A positive coefficient means increasing returns to scale.

Form the results reported in Table 3 for the Kolkata cluster, it is seen that the lagged dependent variable coefficient at GMM estimate is not free from the sample bias because it lies below the WG estimate. This implies that the instruments used here for the estimation of first difference GMM are not providing sufficient information to estimate the labor productivity. However, the OLS and WG lagged dependent variable coefficients are found to be statistically significant with expected sign. The results indicate that in the Kolkata cluster, labor productivity of domestic firms is significantly affected by cluster and region-specific technological stock. The influence of region-specific foreign presence and other industry foreign presence on the domestic firms' productivity is found to be statistically significant with non-negative coefficients. In fact, both the estimated coefficients in the first difference GMM estimates are not free from the sample bias. Further, given these estimates and even allowing for a sample bias, there is still clear existence of a spillover effect in this cluster in view of the significant and non-negative coefficients of these two variables. In addition, it appears from the results that the domestic firms' productivity has been enhanced by the presence of foreign firms in the eastern region and 'other industry' foreign presence in the cluster.

For the Kolkata cluster, the results in respect of the concentration variable is the similar to that for the clusters in the northern region cluster that is the concentration index is not statistically significant. Also, the results do not show any significant advantage accruing to the firm in being located in the centre of a cluster and nearer to the cluster or in urban area rather than the rural area. Firm location within the cluster does not seem to make much difference in terms of the benefits derived from the foreign firms through knowledge and technology spillover.

From the reported results in Tables 3 and 4, we analyze the inter-cluster technology spillover of the western region. For the two western region clusters covered in the study, Ankleswar and Thane, the first and third kinds of horizontal FDI do not have any significant effect on domestic firms' labour productivity. Both clusters show a low level of spillover in comparison to the clusters of other regions. One critical reason is that in these clusters the number of foreign firms' present is relatively low. However, in Thane and Ankleswar clusters, the coefficients of region-specific horizontal FDI are found to be statistically significant in the OLS estimate. One may infer accordingly that domestic firms in the clusters of the western region benefit more from the foreign firms' presence in the western region as a whole rather than their own cluster-specific presence of foreign firms.

Table 3: *Model Estimates, Kolkata and Ankleswar Clusters*

Dependent variable: ln y^{d}_{ijkt}

	Kolkata			*Ankleswar*		
Estimation	*OLS*	*WG*	*GMM (Diff.)*	*OLS*	*WG*	*GMM (Diff.)*
Observations	105	105	75	200	200	167
Ln $y^{d}_{ijk,t-1}$	0.802* (0.045)	0.378* (0.079)	0.092 (0.182)	0.895* (0.029)	0.552 (0.065)	0.233 (0.190)
R_{kt}	0.028** (0.058)	-14.968 (16.138)	0 .159*** (0.109)	0.001 (0.063)	0.018 (0.066)	0.021 (0.062)
R_{ht}	0.070** (0.215)	30.570 (32.902)	0.570 (0.022)	0.788 (1.136)	0.389 (1.105)	-0.154 (0.978)
R_{lt}	0.040* (0.175)	-6.368 (2.866)	-6.589 (7.149)	-0.752 (1.064)	-0.183 (0.518)	0.075 (0.461)
ln K/L_{ijkt}	0.119* (0.049)	0.368* (0.084)	0.301 (0.402)	0.111* (0.026)	0.106** (0.052)	0.188* (0.056)
ln K_{ijkt}	0.007 (0.017)	0.372* (0.083)	0.094 (0.408)	-0.005 (0.008)	0.073*** (0.052)	0.148* (0.062)
H_FDI_{jkt}	0.211 (0.291)	1.301 (1.061)	4.073 (3.361)	-1.253* (0.260)	-1.443* (0.494)	-1.109** (0.592)
H_FDIR_{jht}	0.292 (0.360)	0.021 (1.102)	2.437*** (1.910)	0.409* (0.177)	2.652*** (1.506)	2.491*** (1.839)
H_FDIO_{jkt}	0.449*** (1.119)	-0.104 (8.331)	8.658*** (6.187)	0.008 (1.835)	-0.238 (1.856)	-0.604 1.607
CON_{jkt}	0.146 (0.261)	0.366 (0.625)	-0.1476 (1.672)	0.200*** (0.131)	1.723*** (1.080)	1.902** (1.027)
$D1_{ij}$	-0.246*** (0.159)			-0.149*** (0.087)		
$D2_{ij}$	0.227 (0.176)			0.407* (0.109)		
R^2	0.836	0.335 (overall)		0.956	0.384 (overall)	
Sargan test of restriction			0.006 (p-value)			0.000 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. For the cluster Kolkata, the GMM-Difference instruments are;

$y^{d}_{ijk,t-1}$, $H\_FDI_{jk,t-1}$, $H\_FDIR_{jh,t-1}$, $H\_FDIO_{jk,t-1}$.

The GMM-Difference instruments for Ankleswar cluster regression are;

$y^{d}_{ijk,t-1}$, $CON_{jk,t-1}$, $K/L_{ijk,t-1}$, $K_{ijk,t-1}$,

$H\_FDI_{jk,t-1}$, $H\_FDIR_{jh,t-1}$, $H\_FDIO_{jk,t-1}$, $R_{k,t-1}$, $R_{h,t-1}$, $R_{l,t-1}$.

Table 4: *Model Estimates, Thane and Chennai Clusters*

Dependent variable: $\ln y^{d}_{ijkt}$

	Thane			*Chennai*		
Estimation	*OLS*	*WG*	*GMM (Diff.)*	*OLS*	*WG*	*GMM (Diff.)*
Observations	155	155	126	148	148	126
$\ln y^{d}_{ijk,t-1}$	0.751* (0.041)	0.387 (0.066)	0.212 (0.165)	0.780* (0.051)	0.385* (0.081)	0.132 (0.114)
R_{kt}	-0.014 (0.062)	0.012 (0.069)	0.051 (0.075)	0.624 (0.869)	-0.303 (0.835)	-0.534 (0.731)
R_{ht}	-0.183 (0.861)	-0.603 (0.904)	-1.022 (0.913)	-2.879 (6.361)	3.692 (6.210)	4.748 (5.447)
R_{lt}	0.194 (0.825)	0.317 (0.438)	0.523 (0.446)	2.209 (5.466)	1.664 (2.675)	-2.047 (2.346)
$\ln K/L_{ijkt}$	0.107* (0.043)	0.248* (0.072)	0.320* (0.093)	0.112* (0.045)	0.444* (0.091)	0.601* (0.099)
$\ln K_{ijkt}$	-0.024 (0.019)	-0.172* (0.062)	0.262* 0.084	0.030* (0.016)	0.079 (0.060)	0.102* (0.064)
H_FDI_{jkt}	0.143 (0.444)	0.171 (0.897)	0.013 (1.032)	0.184** (0.245)	0.161* (0.451)	0.398 (0.456)
H_FDIR_{jht}	0.556** (0.259)	1.799 (2.098)	0.945 (2.625)	0.056 (0.258)	0.202 (1.204)	0.309 (1.198)
H_FDIO_{jkt}	-0.451 (0.716)	-2.685* (1.198)	-2.227 (1.624)	0.170 (0.524)	-0.800 (0.601)	-0.712 (0.529)
CON_{jkt}	0.104 (0.201)	-6.780 (3.080)	-4.210 (3.600)	0.478 (0.421)	1.212** (0.597)	-2.296* (0.782)
$D1_{ij}$	0.164 (0.141)			0.032 (0.176)		
$D2_{ij}$	-0.093 (0.157)			-0.178 (.171)		
R^2	0.841	0.611 (overall)		0.892	0.759 (overall)	
Sargan test of restriction			0.000 (p-value)			0.000 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. The GMM-Difference instruments for the Thane and Chennai clusters regressions are;

$y^{d}_{ijk,t-1}$, $CON_{jk,t-1}$, $K/L_{ijk,t-1}$, $K_{ijk,t-1}$,
$H\_FDI_{jk,t-1}$, $H\_FDIR_{jh,t-1}$, $H\_FDIO_{jk,t-1}$, $R_{k,t-1}$, $R_{h,t-1}$, $R_{l,t-1}$.

The coefficients of different kinds of technological stock variables are found to be statistically insignificant for the Ankleswar and Thane clusters. Hence, there are indications from the results that the regional R&D expenditure does not have much effect on the productivity of domestic firms in these clusters. The coefficient of the second dummy variable relating to investment climate for Ankleswar cluster is non-negative and statistically significant. This indicates that the firm's plant location in the rural area is disadvantageous in terms of their labour productivity in comparison to the city area plant location of firms.

The result reported in Tables 4 and 5 provide an analysis of technology spillovers across southern region clusters. All southern region clusters show a relatively higher impact of technology spillover on labor productivity. If we make comparison between Hyderabad and Bangalore clusters, then the spillovers appear to he greater in Bangalore, since the coefficients of all three kinds of horizontal FDI are non-negative and statistically significant in the OLS estimates for Bangalore, but this is not so for Hyderabad. This line of reasoning suggests that domestic firms in these areas get benefit from their cluster and region-specific foreign presence, which leads to technology spillover and raises their productivity level. This may be contrasted to the Chennai cluster. In this case, only the cluster specific horizontal FDI is found to bear a significant effect on productivity. It is also interesting to note that while technology stock (R&D expenditure) has a significant effect on productivity of domestic firms in the Bangalore and Hyderabad clusters, there is no significant effect in the Chennai cluster.

In Bangalore cluster, the lagged dependent variable coefficient of difference GMM estimate is relatively closer to the WG estimate in comparison to the other clusters of southern region. This suggests that all the lagged exogenous instruments which have been used here are quite substantial and provide useful results for the estimation of labor productivity and technology spillover. Thus, inclusion of the lagged endogenous variable in the dynamic model is more effective and quite relevant for the determination of technology spillover in Bangalore cluster. The study gets relevance result for capital stock and capital intensity variables across all clusters in the southern region. However, in some instances, these estimated coefficients are not free from the sample bias. In fact, all estimated coefficients of capital and capital intensity are significant at the OLS estimates for Chennai and Hyderabad, but not for Bangalore. The coefficients are statistically significant for all three clusters in the GMM estimates. Hence, it follows that capital intensity is a key determinant of labor productivity of domestic firms in these clusters. The significant positive coefficient of the capital stock variable signifies the presence of scale economies.

Table 5: *Model Estimates, Hyderabad and Bangalore Clusters*

Dependent variable: $\ln y^{d}_{ijkt}$

	Hyderabad			*Bangalore*		
Estimation	*OLS*	*WG*	*GMM (Diff.)*	*OLS*	*WG*	*GMM (Diff.)*
Observations	187	187	155	228	228	187
$\ln y^{d}_{ijk,t-1}$	0.881* (0.025)	0.686* (0.064)	0.240* (0.086)	0.860* (0.027)	0.474* (0.062)	0.396* (0.096)
R_{kt}	-0.062 (0.059)	0.003 (0.077)	0.187* (0.070)	0.297 (0.247)	3.527*** (2.49)	3.079*** (2.181)
R_{ht}	0.336*** (0.192)	0.082 (0.290)	1.025* (0.296)	0.787 (0.703)	11.722*** (8.180)	10.313*** (7.157)
R_{lt}	-0.099 (0.156)	-0.033 (0.080)	0.123** (0.062)	0.410 (0.419)	3.967*** (2.851)	3.428*** (2.501)
$\ln K/L_{ijkt}$	0.045*** (0.032)	0.166** (0.087)	0.553* (0.099)	0.060** (0.030)	0.272* (0.080)	0.406* (0.084)
$\ln K_{ijkt}$	0.026*** (0.018)	-0.050 (0.110)	0.727* (0.150)	-0.012 (0.010)	0.322* (0.045)	0.406* (0.049)
H_FDI_{jkt}	0.024 (0.251)	2.230*** (1.268)	1.697*** (1.229)	0.133*** (0.193)	1.188*** (0.737)	0.893 (0.837)
H_FDIR_{jht}	0.037 (0.261)	0.263 (2.319)	4.175** (2.122)	0.447* (0.179)	2.389*** (1.601)	1.009 (1.783)
H_FDIO_{jkt}	1.625 (1.394)	3.476 (2.824)	-1.047 (2.784)	0.531*** (0.813)	2.031 (2.725)	0.9005 (2.560)
CON_{jkt}	0.503*** (0.299)	0.571 (0.561)	1.009** (0.501)	0.037 (0.166)	0.411 (0.673)	0.122 (0.665)
$D1_{ij}$	-0.005 (0.140)			-0.010 (0.106)		
$D2_{ij}$	-0.001 (0.147)			-0.011 (0.108)		
R^2	0.909	0.722 (overall)		0.875	0.378 (overall)	
Sargan test of restriction			0.001 (p-value)			0.000 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. The GMM-Difference instruments for the Hyderabad and Bangalore clusters regressions are;

$CON_{jk,\ t-1}$, $K/L_{ijk,t-1}$, $K_{ijk,t-1}$,

$H\_FDI_{jk,t-1}$, $H\_FDIR_{jh,t-1}$, $H\_FDIO_{jk,t-1}$, $R_{k,t-1}$, $R_{h,t-1}$, $R_{l,t-1}$

The coefficients of concentration index are found to be positive and statistically significant for the Hyderabad cluster. Such results are not found for the other two clusters in southern region. Therefore, the analysis points to the favorable effect of market concentration on the ratio of value added to employment in domestic firms in Hyderabad. Such effect of market concentration is not found for Bangalore and Chennai. Indeed, in a majority of the clusters of other regions considered in the study, a significant positive effect of market concentration on value added is not found.

The estimated coefficients for the investment climate related dummy variables for the southern region clusters do not provide any substantial support to our hypothesis, that a plant location in the core area of a cluster area or near to the core area is beneficial in comparison to location away from the center of the cluster. Nor, support is found for the hypothesis that firms having plant location in the city areas of a cluster get more benefits from the banking sector and other infrastructure facilities which enhances their productivity as compared to the firms having plant location in rural areas. This is not valid in the southern region clusters, though this does hold for a few clusters in other regions.

VI. Concluding Remarks

Studies on technological spillover often ignore the effect of firm location in being able to gain from the technological spillovers from the presence of foreign firms. It stands to reasons that *ceteris paribus* a firm geographically located near the foreign firm is more likely to gain from technological spillover than a firm located far away from the foreign firm. The present study attempted to incorporate this aspect into the analysis. We examined inter-cluster technology spillover across ten selected clusters in India.[7] In this work, we were concerned with the evaluation of the technology spillover across different clusters in India, stressing the role of both technological innovation variables (R&D investments made in a cluster and such investments made in a region) and technological

[7] In choosing clusters for the study, the presence of foreign firms was a key consideration. The results of the empirical analysis reveal significant technological spillovers across clusters in a region. Thus, it is possible for firms in a cluster having no foreign firms to gain from the presence of foreign firms in other clusters of the regions. No such cluster has been included in the study, though this could have been done and would have been interesting to do.

spillovers taking place from horizontal FDI in the cluster and in other clusters of the region. The empirical model used related the labor productivity of domestic firms in the selected clusters to technological stock variables, horizontal FDI variables and several other control variables.

The main findings can be summarized as follows:

(i) All four clusters from the northern region show a positive spillover from their regional foreign presence rather than from their own cluster-specific foreign presence. This suggests that domestic firms in a cluster get benefits from their northern region foreign counterparts rather than from their own cluster-specific foreign firms.

(ii) The technology stock of a cluster does not in general exert a strong positive influence on the productivity of the domestic firms across northern region clusters. But, the technology stock of the region matters in some cases. Similarly, cluster specific R&D investment increases labour productivity in some cases.

(iii) The investment climate variable which reflects the scientific, technological, institutional environment like credit facilities of the banking system is quite effective in the Baddi and Bhiwadi clusters. This indicates that firm's plant location in the city/urban areas of a cluster is helpful in making productivity gains through use of infrastructure facilities than the firms having plant located in the rural areas.

(iv) The technology stock in Kolkata cluster affects positively the productivity of domestic firms through technology spillover. Therefore, domestic firms get benefit by devoting more funds for R&D. From the analysis undertaken for the Kolkata cluster, it is apparent that domestic firms get benefit from their region-specific foreign firms rather than the foreign firms which are located in the Kolkata region. Why domestic firms in this cluster cannot absorb the knowledge and technology from their foreign counterparts which have plant locations in the Kolkata cluster, is a moot question.

(v) The study does not get any proper evidence regarding the possible productivity enhancing effect of investment climate in the Kolkata cluster. Rather, it appears from the empirical results that firms plant locations in the core area of a cluster or nearer to the core areas of a cluster does not give any significant advantage to firms located in the

Kolkata cluster. It seems location of the firms in the Kolkata cluster has little impact on the ability of the firm to gain from information and knowledge spillover from the foreign firms in the cluster or in other clusters of the region.

(vi) Neither technology stock nor foreign presence in region and in cluster seems to have much effect on the domestic firms' productivity across the western region clusters. In the Ankleswar and Thane clusters, technology spillover is quite insignificant, probably because of the low presence of foreign firms in this region. Further, it appears from the empirical results for the Ankleswar cluster that firm having their plant located in city are in a position to have higher technology spillovers in comparison to the rural area located firms.

(vii) It appears from the study that technological spillovers to domestic firms in southern region clusters are relatively high in comparison to clusters of other regions in India. This is probably because of the relatively greater presence of foreign firms in the southern region. Further, in a comparison among Bangalore, Chennai and Hyderabad, the extent of technology spillover seems to be relatively greater for the domestic firms in the Bangalore cluster. This is probably attributable to the significant level of foreign presence in this cluster. We do not get much empirical support for the hypothesis that if a firm is located in urban areas of a cluster or in the core part of the cluster, it will have greater scope for gaining from the technological spillovers. Rather, the empirical results seem to suggest that, both rural and city area located firms are almost equal gainer from their foreign counterparts in terms of knowledge and technology spillovers.

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Appendix A

Variables

Dependent Variable

Labor productivity, y_{ijkt}^{d}: Value added per unit of labour of *i*th domestic firms of *j*th industry in the *k*th cluster in year *t*. Here, *t* represents the time subscript over the period 2000 to 2007 i.e., an eight-year period that has been taken into consideration. Labor productivity of the domestic firms is compiled from the Prowess database of the CMIE by dividing the gross value added of domestic firms to the number of man-days (labor) per firm of each industry.

Explanatory variables

Capital K_{ijkt} **:** Capital input has been measured by the value of gross fixed asset at the firm level at the end of each year.

Labor: The 'Prowess' database does not provide information on labor employed per firm. But, for computing labor productivity and capital intensity, we need information on man-days per firm. A rough estimate of man-days at the firm level has been obtained by dividing the salaries and wages at the firm level by the average wage rate of the industry to which the firm belongs, as has been done in several earlier studies based on Prowess. Thus, the formula for computing man-days per firm is given below:

Number of man-days per firm = Salaries and Wages / Average Wage Rate

To get the average wage rate, we have to use data from the *Annual Survey of Industries* (ASI). ASI contains information on total emoluments as well as total man days for relevant industry groups. Hence, the average wage rate (for each industry group for each year) can be obtained by dividing total emoluments to the total man-days for relevant industry groups.

Average Wage Rate = Total emoluments/ Total Man-days

Capital Intensity K/L_{ijkt} **:** Capital intensity of the *i*th firm in *j*th industry in *k*th cluster in different years has been computed by dividing reported fixed capital by the estimated number of man days worked.

Horizontal FDI of the cluster, H_FDI_{jkt} : Horizontal FDI for an industry in a particular cluster is measured by the portion (share) of an industry's output in that particular cluster that is produced by the foreign firms.

$$H\_FDI_{jkt} = \frac{\sum_{i \in jkt} (foreign\_output)_{it}}{\sum_{i \in jkt} (output)_{it}},$$

Where $i \in jkt$ refers to the *i*th firms in *j*th industry in *k*th cluster over different time periods. Thus, the numerator indicates the sum of foreign firm's output of *j*th industry of a given cluster (*k*th) in year t (over time period 2000 to 2007), and the denominator indicates the sum total output of *j*th industry in that cluster (*k*th) in that year.

Horizontal FDI of the Region, H_FDIR_{jht} : Regional horizontal FDI of a given industry has been obtained in the same way as the horizontal FDI of a particular cluster. Thus, the horizontal FDI of a given region has been obtained as:

$$H\_FDIR_{jht} = \frac{\sum_{i \in jht} (foreign\_output)_{it}}{\sum_{i \in jht} (output)_{it}}$$

In this case, the numerator represents the sum of the foreign firms' output in the *j*th industry in a given region *h*, in a particular year t, over time period 2000 to 2007, and the denominator represents the sum of the total output of firms of the region belonging to the *j*th industry in that year. In our study, we consider only four regions, namely north, south, east and west India.

Horizontal FDI of Other industries (third kind of horizontal FDI) H_FDIO_{jkt}**:**

This is the third kind of horizontal FDI that has been compiled for each industry in each cluster to capture the effect of foreign firm's presence in other industries to the domestic firms belonging to a particular industry within the cluster. In our study, we have selected only seven industries to assess technology spillover in a cluster. Suppose we consider the third kind of horizontal FDI for the chemical industry in the BADDI cluster. To compute this kind of horizontal FDI, we take the sum of foreign firm's output of all remaining six industries in the cluster over the time period from 2000 to 2007 (excluding the chemical industry foreign firms output) and then divide it by the sum of output of all firms of the remaining six industries (excluding chemical industry) over this time period. In this way we computed for each year the third kind of horizontal FDI for different industries within a cluster.

Technology Stock of the Cluster, R_{kt} **:** The technology stock of a cluster is obtained by taking the cumulated sum of annual R&D expenditure, following Coe and Helpman (1995) and resorting to a method proposed by the Griliches (1979). Thus, according to this method, the stock of technological knowledge of a firm for the base year of the study is obtained by the following procedure:

$$R_o = \frac{RD_o}{g+d};$$

where RD_o is the R&D expenditure at the time 0, which is 2000 in our case because our coverage of data is from 2000 to 2007, g stands for the growth rate of the R&D expenditure, i.e. $g = \frac{RD_t - RD_{t-1}}{RD_{t-1}}$, and d is the depreciation rate. We use a fixed rate of depreciation of 15%. Having obtained R_o, the technological stock at a subsequent time period t for $t > 0$ is obtained using the following relationship:

$$R_t = (1-d).R_{t-1} + RD_{t-1}$$

The above concept for a firm has been applied to a particular cluster and following this methodology, the technological stock of a given clusters k can be obtained as follows:

$$R_{kt} = (1-d).R_{k,t-1} + RD_{k,t-1}.$$

Here, $R_{k,t-1}$ is the technological stock of the kth cluster at the period $t-1$, and $RD_{k,t-1}$ is the R&D expenditure of all those firms that are part of the kth cluster in the time period $t-1$.

Technology Stock of the Region, R_{ht} **:** The methodology described above has been used to construct the technological stock of a given region h which is obtained as:

$$R_{ht} = (1-d).R_{h,t-1} + RD_{h,t-1}.$$

In the above equation, $R_{h,t-1}$ denotes the technological stock of a region h in the previous year and $RD_{h,t-1}$ is the sum of annual R&D expenditure of all firms in all selected industries within that region in the time period $t-1$. In this manner, a region-specific technological stock has been obtained with the help of the annual R&D expenditure of all firms of all selected industries within that region.

Market Concentration, CON_{jt} **:** This is another kind of the cluster-specific effect, and it is obtained by the Herfindahl–Hirschman index (*HHI*) of market concentration.[8] The formula for the HHI concentration index, computed separately for each industry j in a cluster is:

$$HHI = \sum_i \left(\frac{S_{ijk}}{\sum S_{ijk}} \right)^2$$

[8] For the estimation of the market concentration of an industry, studies generally use the Herfindahl-Hirschman index (HHI) as the concentration index. In our study too, we have applied this methodology to find out the technology spillover of a cluster and control for differences in market concentration which is obviously an important factor influencing the domestic firms' labor productivity. It should be noted here that we are computing HHI for firms belonging to an industry and located in a particular cluster which is different from the HHI for an industry at the All India or regional level.

where, S_{ijk} is the sales of the *i*th firm in the *j*th industry of a cluster *k*. And the denominator is the summation over the sales of all firms in the *j*th industry within that cluster.

Dummy variables

$D1_{ij}$: This is a dummy variable related to plant location in the cluster. It takes value one if the plant of the firm is located within 40 km radius from the core part (or the urban part) of the cluster, and value zero for firms whose plants are not geographically not so located. Our hypothesis is that being closer to the core part of the cluster gives advantages to a firm in comparison to firms that are located far from the core part of the cluster.

$D2_{ij}$: This dummy variable is also connected with location of the plants. However, it is more intimately connected with infrastructure availability, such as credit and banking infrastructure of the clusters. We hypothesize that firms whose plant location is in urban area of a cluster can have greater advantage in comparison to those firms but located in the country side. This is so because banking infrastructure is more efficient in the city/urban area in comparison to the rural area. Also, location in urban area may provide advantages regarding roads, electricity, communication etc. Thus, for firms whose plant location is in the city/urban area of a cluster, the dummy variable takes value one and for firms whose plant location is in the rural area, the dummy variable takes value zero. It should be noted that this dummy variable overlaps to some extent with the previous dummy variable. But, these are not the same. A firm in rural area could be within 40 km radius from the core part of the cluster. Thus, even though the firm is in rural areas, its geographical proximity to the core of the cluster may give some advantages over the firm that are located in rural area and are away from the core of the cluster.

Appendix B

Table B1

Classification of Firms (Out of Selected Seven Industries) in the Different Selected Clusters in India

Clusters	*Domestic firms*	*Foreign firms*	*Total firms*
Baddi (NR)	39	4	43
Noida (NR)	35	6	41
Gurgaon (NR)	37	11	48
Bhiwadi (NR)	21	3	24
Thane (WR)	33	2	35
Ankleswar (WR)	35	5	40
Kolkata (ER)	35	10	45
Chennai (SR)	29	14	43
Hyderabad (SR)	32	7	39
Bangalore (SR)	51	20	71

Source and Note: 1. Own compilation from the CMIE data set ‘Prowess’.
2. NR, WR, ER, and SR stand for northern region, western region, eastern region and southern region in India.